

Pacific University

CommonKnowledge

---

College of Optometry

Theses, Dissertations and Capstone Projects

---

5-2003

## Computer based approach to graphical analysis: A Microsoft Excel application

Nathan Heilman  
*Pacific University*

### Recommended Citation

Heilman, Nathan, "Computer based approach to graphical analysis: A Microsoft Excel application" (2003).  
*College of Optometry*. 1436.  
<https://commons.pacificu.edu/opt/1436>

This Thesis is brought to you for free and open access by the Theses, Dissertations and Capstone Projects at CommonKnowledge. It has been accepted for inclusion in College of Optometry by an authorized administrator of CommonKnowledge. For more information, please contact [CommonKnowledge@pacificu.edu](mailto:CommonKnowledge@pacificu.edu).

---

## Computer based approach to graphical analysis: A Microsoft Excel application

### Abstract

This Graphical Analysis program was designed using both Microsoft Excel and Visual Basic for Applications. The primary purpose for the creation of this program was to provide both the optometric student and the established clinician with a quicker, more efficient, and flexible means of utilizing traditional reserve-demand systems of case analysis for educational, clinical and research purposes. Presently, the complete application of graphical analysis and comfort criteria is largely confined to academic settings since it can be unacceptably time consuming. In the fast paced world of modern vision care, it is understandable why many case analysis systems have been largely ignored or forgotten. Granted, some analysis of optometric data and application of comfort criteria can be applied without using difficult calculations; however, it is the belief of the author that a more comprehensive use of analysis systems will be possible in clinical settings via the utilization of this and other computer based systems of analysis. In fact, it is proposed that the conscientious student and practitioner will be able to utilize the tools contained in this program to arrive at more informed management decisions in shorter amounts of time. By simply entering examination data, the clinician/student is allowed to view an instant graphical plot of the patient's data as well as calculations of Sheard's, Percival's and Saladin's comfort criteria. In addition, there is a separate section designed for the use of Pratt's criterion via both graphical and numerical methods. For the student, this program provides an effective means for learning the relationships of accommodation and vergence and exploring the theories behind lens and prism therapy in the alleviation of nonstrabismic binocular vision disorders. For the established clinician, this program provides an efficient means of determining data reliability, quickly calculating possible lens and/or prism prescriptions, and electronically archiving analyzed patient data.

### Degree Type

Thesis

### Degree Name

Master of Science in Vision Science

### Committee Chair

Scott Cooper

### Subject Categories

Optometry

### Copyright and terms of use

If you have downloaded this document directly from the web or from CommonKnowledge, see the "Rights" section on the previous page for the terms of use.

**If you have received this document through an interlibrary loan/document delivery service, the following terms of use apply:**

Copyright in this work is held by the author(s). You may download or print any portion of this document for personal use only, or for any use that is allowed by fair use (Title 17, §107 U.S.C.). Except for personal or fair use, you or your borrowing library may not reproduce, remix, republish, post, transmit, or distribute this document, or any portion thereof, without the permission of the copyright owner. [Note: If this document is licensed under a Creative Commons license (see "Rights" on the previous page) which allows broader usage rights, your use is governed by the terms of that license.]

Inquiries regarding further use of these materials should be addressed to: CommonKnowledge Rights, Pacific University Library, 2043 College Way, Forest Grove, OR 97116, (503) 352-7209. Email inquiries may be directed to: [copyright@pacificu.edu](mailto:copyright@pacificu.edu)

# Computer Based Approach to Graphical Analysis

A Microsoft® Excel Application

By

Nathan Heilman

A thesis submitted to the faculty of the  
College of Optometry  
Pacific University  
Forest Grove, OR  
For the degree of  
Doctor of Optometry  
May 2003

Advisor:  
Scott C. Cooper, O.D., M.Ed.

# Computer Based Approach to Graphical Analysis

A Microsoft<sup>®</sup> Excel Application

By

Nathan Heilman

Student:

A handwritten signature in cursive script, appearing to read 'Nathan Heilman', written over a horizontal line.

Nathan P. Heilman

Advisor:

A handwritten signature in cursive script, appearing to read 'Scott C. Cooper', written over a horizontal line.

Scott C. Cooper, O.D., M.Ed.

#### About the Author:

Nathan Heilman received his Bachelor of Arts degree in 1999 graduating summa cum laude from Augustana College in Sioux Falls, SD. While attending Augustana, he was the recipient of sophomore honors and achieved membership in the Augustana Honor Society, Blue Key Men's Honor Society, and Beta Beta Beta Biology Honor Society. After completing his undergraduate studies, Nathan was awarded a full academic scholarship to the Pacific University College of Optometry in Forest Grove, OR from the US Navy's Health Professions Scholarship Program. He is currently a member of Beta Sigma Kappa International Optometric Society and upon graduation from Pacific University, Nathan will enter optometric practice as a naval officer.

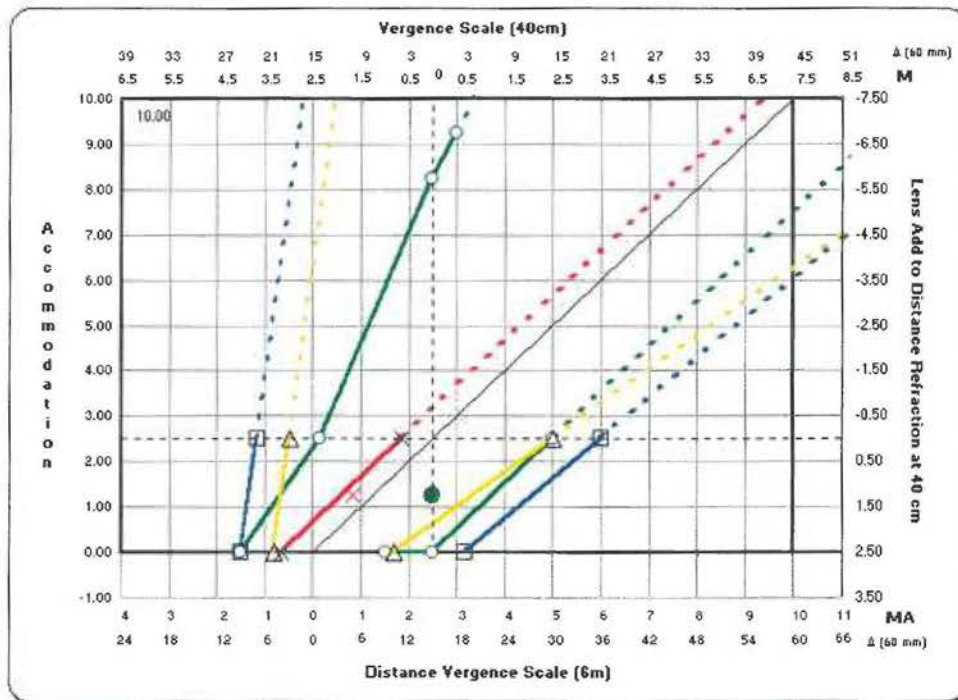
## Abstract:

This Graphical Analysis program was designed using both Microsoft Excel and Visual Basic for Applications. The primary purpose for the creation of this program was to provide both the optometric student and the established clinician with a quicker, more efficient, and flexible means of utilizing traditional reserve-demand systems of case analysis for educational, clinical and research purposes.

Presently, the complete application of graphical analysis and comfort criteria is largely confined to academic settings since it can be unacceptably time consuming. In the fast paced world of modern vision care, it is understandable why many case analysis systems have been largely ignored or forgotten. Granted, some analysis of optometric data and application of comfort criteria can be applied without using difficult calculations; however, it is the belief of the author that a more comprehensive use of analysis systems will be possible in clinical settings via the utilization of this and other computer based systems of analysis. In fact, it is proposed that the conscientious student and practitioner will be able to utilize the tools contained in this program to arrive at more informed management decisions in shorter amounts of time. By simply entering examination data, the clinician/student is allowed to view an instant graphical plot of the patient's data as well as calculations of Sheard's, Percival's and Saladin's comfort criteria. In addition, there is a separate section designed for the use of Pratt's criterion via both graphical and numerical methods.

For the student, this program provides an effective means for learning the relationships of accommodation and vergence and exploring the theories behind lens and prism therapy in the alleviation of nonstrabismic binocular vision disorders. For the established clinician, this program provides an efficient means of determining data reliability, quickly calculating possible lens and/or prism prescriptions, and electronically archiving analyzed patient data.

# Computer Based Approach to Graphical Analysis



A Microsoft<sup>®</sup> Excel Application

by

Author: Nathan P. Heilman

Advisor: Scott C. Cooper, O.D., M.Ed.



## Introduction:

The primary purpose for the creation of this program was to provide both the optometric student and the established clinician with a quicker, more efficient, and more flexible means of utilizing traditional reserve-demand systems of case analysis for educational, clinical and research purposes.

Presently, the complete application of graphical analysis and comfort criteria is largely confined to academic settings since it can be unacceptably time consuming. In the fast paced world of modern vision care, it is understandable why many case analysis systems have been largely ignored or forgotten. Granted, some analysis of optometric data and application of comfort criteria can be applied without using difficult calculations; however, it is the belief of the author that a more comprehensive use of analysis systems will be possible in clinical settings via the utilization of this and other computer based systems of case analysis. In fact, it is proposed that the conscientious student and practitioner will be able to utilize the tools contained in this program to arrive at more informed management decisions in shorter amounts of time. By simply entering examination data, the clinician/student is allowed to view an instant graphical plot of the patient's data as well as calculations of Sheard's, Percival's and Saladin's comfort criteria. In addition, there is a separate section designed for the use of Pratt's criterion via both graphical and algebraic methods.

For the student, this program provides an effective means for learning the relationships of accommodation and vergence and exploring the theories behind lens and prism therapy for the alleviation of nonstrabismic binocular vision disorders. For the established clinician, this program provides an efficient means of determining data reliability, quickly calculating possible lens and/or prism prescriptions, and electronically archiving analyzed patient data.

This Graphical Analysis program was designed using both Microsoft Excel and Visual Basic for Applications. Since this program is run on a Microsoft software platform, it avoids most, if not all, cross-platform issues between Macintosh and PC based computer systems. It is also assumed that this program will be equally accessible on future versions of Microsoft® Excel as they become available.

At the present time, this program can be accessed by students of the Pacific University College of Optometry through the "Matilda" server, which can be accessed via the Local Area Network in Jefferson Hall on Pacific University's campus. To access the program in this manner follow the following network path:

1. Access the Matilda server on Jefferson Hall's Local Area Network
  - Open the following path on Matilda: \Teaching\cooper\_s\Analysis Tools\_Worksheets\Graphical\Graph Analysis.xls

A hard copy of this program is also on file at the Pacific University's Harvey Scott Library. Although there is a CD with the final thesis inserted into the book cover, it might not be the most up to date or "bug-free" version available.

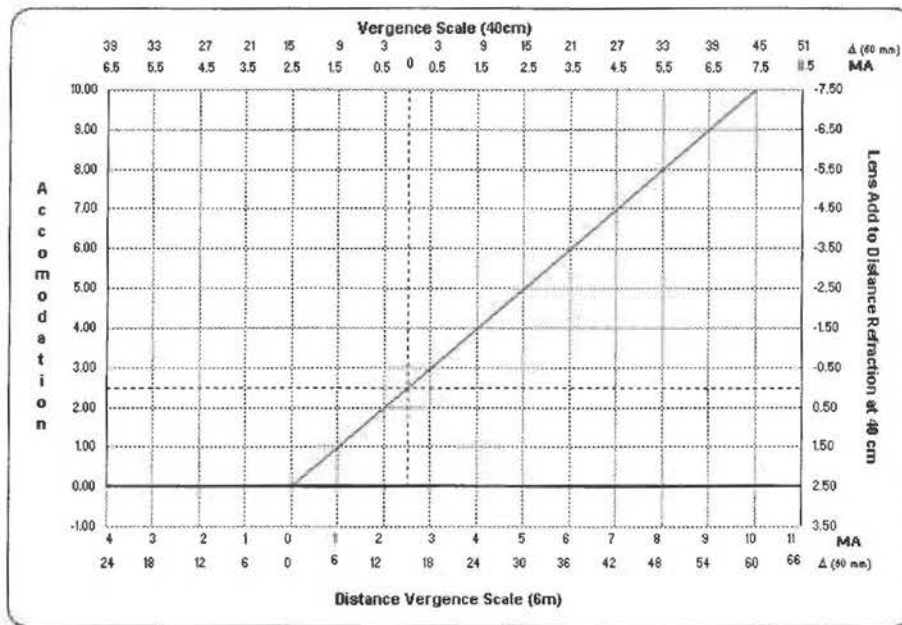
Those who cannot access the program by the above means can obtain a copy of this program by contacting Professor Scott C. Cooper at the Pacific University College of Optometry.

### Contact Information:

Scott C. Cooper, O.D., M.Ed.  
Pacific University College of Optometry  
2043 College Way  
Forest Grove, OR 97116  
Office Phone: (503) 359-2771  
E-mail: [coopers@pacificu.edu](mailto:coopers@pacificu.edu)

**Disclaimer:** This program has been designed to provide its users with both functionality and ease of use. However, some may find that this program is not without its shortcomings in some areas. It is assumed that users are already familiar with the use and application of graphical analysis. For suggestions on how to improve this program or to inquire about updated versions, please contact Scott Cooper via the above contact information.

## Components of the graph:



### X-axis: Vergence Demand/Response Scale

The scales on the top and bottom of the graph are scaled in both prism diopters (for a 60 mm interpupillary distance) and meter angles. The bottom axis and legend represent vergence demands relative to distance, and the top axis and legend represent vergence demands relative to near using the 40 cm scale at the top of the graph. This is easily realized by observing that the vertical dotted line (near demand line) represents a near demand of 0 $\Delta$  (0 MA) and a distance demand of 15 $\Delta$  (2.5 MA). In order to avoid inaccuracies of plotting due to the affect of interpupillary distance on vergence demand, the program plots vergence data points in meter angles (MA). Using a method that is often applied for practical reasons, meter angles are calculated from phoria and vergence data using a 60 mm interpupillary distance unless the patient's interpupillary distance is equal to or less than 52 mm or equal to or greater than 68 mm.

### Primary Y-axis: Accommodative Demand/Response

The primary y-axis, (left-hand edge) represents the accommodative demand required for a particular distance relative to infinity.

### Secondary Y-axis: Lens Add to Distance Refraction

The secondary y-axis (right-hand edge) represents the amount of minus or plus added to the distance refraction. Note that the zero point of this scale coincides with an accommodative demand of 2.50 D (40 cm). If any other testing distance is utilized for near testing, this scale will not be valid.

### Demand Line

The 45° demand line represents the free-space combination of accommodative and vergence stimuli required for any target distance. This line is strongly influenced by a person's interpupillary distance. To prevent this from affecting the accuracy of the graph, the program plots vergence data in meter angles using the interpupillary distance consideration explained above within the X-axis description. At present, the graph only plots near vergence measures relative to a 40 cm testing distance. It should also be noted that the prism scales provided are only accurate for someone with a distance interpupillary distance of 60 mm.

# What Gets Plotted and How?

All of the data utilized for plotting the graph is binocular data. No data from monocular testing is included. Before being able to view the graph, the program will prompt you for information it needs before the complete graph can be plotted. The following components make up a complete graph:

## 1. Upper Limit of the Plot: Accommodative Amplitude

The patient's accommodative amplitude is represented on the graph by a thick horizontal black line at the highest documented amplitude. In order to plot the accommodative amplitude, only one of three values must be known and entered. These three values are the Donder's Push Up Amplitude in centimeters, the Analytical Amplitude (OEP #19) endpoint in diopters, and the Positive Relative Accommodation (OEP #20) endpoint in diopters. If all three of these values are entered, the program will select the largest of the three values to represent the patient's accommodative amplitude.

- Donder's Accommodative Amplitude is calculated by taking the reciprocal of the near distance in meters where the patient was no longer able to resolve 0.62 M print.
- In order to calculate the accommodative amplitude from the Analytical Amplitude (AA), the dioptric difference between the AA's OD gross spherical lens value and the Distance Subjective's OD gross spherical value is calculated. This lens difference is added to a constant value of 3.00 D to account for the 33 cm testing distance.
- The accommodative amplitude calculation using the PRA is identical to that used for the AA with the exception that a 2.50 D constant is used to account for the 40 cm testing distance.

## 2. Right Hand Limit of the Plot: Near Point of Convergence (NPC):

The maximum amount of convergence available to the patient is represented by a thick vertical black line on the right hand side of the graph. This value is calculated in meter angles by taking the reciprocal of the NPC *Break* value in meters. Note that the recovery value is not at all involved in this calculation.

## 3. Induced Distance (Free-Posture) Phoria (OEP #8):

This is the phoria value measured at distance through the distance subjective refraction. This value is represented by a red X along the x-axis at the zero accommodative demand level (assuming no accommodation is in play while viewing a distance target).

## 4. Distance Vergence Ranges (OEP #9, 10, and 11):

These are base in and base out vergence ranges measured relative to distance with the distance subjective refraction in place.

The first noticeable Blur, Break, and Recovery values are represented along the x-axis at the zero accommodative demand level by a circle, square, and triangle respectively on both sides of the demand line. However, no blur value should occur during distance BI vergence ranges; therefore, no circle will be present on the left side of the demand line along the x-axis.

## 5. Negative Relative Accommodation (OEP #21):

This is the binocular plus to 20/20 blur out OD gross sphere value compared to the distance subjective OD sphere value to arrive at a net value, which is plotted on the graph.

This data point is indicated by a circle plotted along the near vergence demand line (dotted vertical line) and below the dotted accommodative demand line, which represents the accommodative demand during near testing.

## **6. Positive Relative Accommodation (OEP #20):**

The binocular minus to 20/20 blur out OD gross sphere value is compared to the distance subjective OD sphere value to arrive at a net value, which is plotted on the graph. This data point is indicated by a circle plotted along the near vergence demand line (dotted vertical line) using the 40 cm test scale of the secondary y-axis.

## **7. Analytical Amplitude (OEP #19):**

The binocular analytical amplitude OD gross sphere value is compared to the distance subjective OD sphere value to arrive at a net value, which is plotted on the graph.

This data point is indicated by a circle plotted along the vertical 3 MA line with respect to the intersection with the demand line. This is in contrast to the NRA and PRA which are both plotted along the vertical 2.5 MA line. This is because the AA test is traditionally administered at a distance of 33 cm.

If there is no #19 value entered, then the #19 value will default to the PRA value. As a result, there will still be a data point present on the graph for the #19, but it will appear directly to the right of the PRA data point. While this might seem odd or misleading to plot a non-existent data point, at the time of this project, it was a necessary compromise to move the project forward.

## **8. Induced Near (Free-Posture) Phoria (OEP #13b):**

This is the phoria value measured at near through the distance subjective refraction. This value is represented by a red X along the dotted near accommodative demand line utilizing the 40 cm vergence scale along the top of the graph.

## **9. Near Vergence Ranges (OEP #16a-b and 17a-b):**

These are the base in and base out vergence ranges measured at near. Typically, they are measured with the distance subjective refraction in place.

The Blur, Break, and Recovery values are represented along the dotted accommodative demand line by a circle, square, and triangle respectively on both sides of the 40 cm demand line.

## **10. Near Fused Cross Cylinder (OEP #14b):**

The #14b OD gross lens value is compared to the OD distance refraction lens to arrive at a net which is plotted on the graph.

This value is represented by a green circle plotted vertically along the near vergence demand line (dotted vertical line). It can appear either above or below the dotted near accommodative demand line depending on the actual test result.

## **11. Near Fused Cross Cylinder Induced (Free-Posture) Phoria (OEP #15b):**

This is the phoria value measured at near through the near fused crossed cylinder (#14b) lenses.

This value is represented by a red X at the same accommodative level as the #14b net value (green circle) utilizing the 40 cm vergence scale.

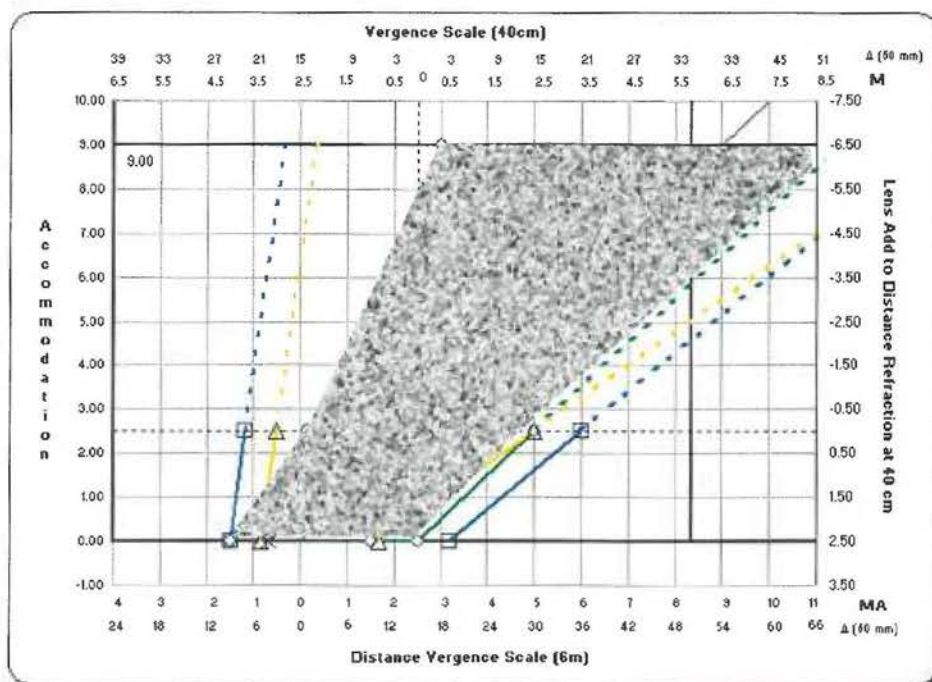


# Zone of Clear Single Binocular Vision

## 1. The Five Components of the Zone:

- PRV blur (defines the right hand border of the zone)
- NRV blur (defines the left hand border of the zone)
- Accommodative Amplitude (defines the top border of the zone)
- Distance Phoria (defines the left-right position of the zone on the graph)
- AC/A or near phoria (determines the slope of the graph)

The above five elements serve to define the position, slope, and size of the Zone of Clear Single Binocular Vision (ZCSBV). The ZCSBV defines the combinations of accommodative and vergence demands a person is theoretically able to clear and fuse efficiently and comfortably. This area is represented by the shaded area in the graph below.



It should be mentioned that the graphical representation of the ZCSBV does not mean he or she will absolutely have clear, single binocular vision within that zone. Graphical analysis does not take into account a patient's recovery skills or control of fusion and accommodative skills. Therefore, a person can have a wide ZCSBV but still have problems due to poor sustaining ability, facility, or overall control of accommodation and motor and sensory fusion.

## Comfort Criteria and Prescription Criteria:

Throughout Optometry's life span, there has been much research and speculation into the interplay between accommodation and vergence. Questions that optometrists want to answer in regard to these two systems are 1) How do they work together? 2) What happens when they don't work correctly? and 3) When things do go wrong, what can be done to help restore the balance and/or alleviate symptoms resulting from misbehavior of accommodation and vergence?

Past research has provided generally acceptable answers to the first two questions; however, when it comes to the treatment of accommodative and vergence anomalies, there is some amount of disagreement. This disagreement mainly concerns the manner in which a clinician arrives at what he/she believes to be an effective combination of lenses and prisms. Consequently, dozens of comfort and prescriptive criteria have been fabricated. Comfort criteria are primarily aimed at predicting when visual symptoms related to accommodation and vergence will be present. Also, comfort criteria may be utilized to discriminate between visual skill deficits or other problems as the cause of a patient's symptoms. In contrast to comfort criteria, prescriptive criteria are not designed to predict the presence or absence of symptoms. They are intended to derive a lens and/or prism prescription that will help to relieve a patient's symptoms when symptoms are present or to optimize visual efficiency.

The following comfort and prescriptive criteria here have acquired more clinical acceptance over time and have been shown to be useful for diagnosis, prescription, or both.

### Donder's Accommodative "Comfort" Criterion:

*The accommodative demand should be no more than one-half of the available amplitude.*

This criterion tends to serve a dual role as both a comfort and a prescription criterion. It is most useful when determining an add necessary for a presbyopic prescription since it is almost always within 0.25 D of the best presbyopic add. Donder's criterion is not a very useful tool for predicting comfort or prescriptions for pre-presbyopes when an ample amount of accommodation is available to them.

**Formula used:**  $\text{Add} = \text{Demand} - \text{Amplitude}/2$

### Sheard's Comfort Criteria:

*The fusional vergence demand should be at least twice as great as the opposing phoria.*

In reserve-demand systems of case analysis, phorias represent a demand that must be overcome by an equal and opposite amount of fusional vergence (represented by the opposing vergence blur value). Esophoria requires fusional divergence and exophoria requires fusional convergence to maintain binocular fixation. According to this criterion, visual symptoms will result when fusional vergence reserve (the amount of fusional vergence left over after the phoria has been overcome) is less than twice the magnitude of the phoria.

Today, the primary intent of this criterion is to predict those exophoric patients who will or will not have asthenopia at the nearpoint. It is best used to predict asthenopia in cases of moderate to high exophoria and its predictive value diminishes significantly in cases of low exophoria and esophoria. The criterion was never intended to be used at distance, and it was never intended to be used as a prescriptive criterion for prism in part, because it is looking for minimum requirements, not optimal benefits. Despite these original intentions of Sheard's criterion, it is often utilized in clinical practice both as a comfort criterion at distance and near, and as a prescriptive criterion for prism. The graphical analysis program provides evaluation of Sheard's for both distance and near calculating both a prism value and a lens value that satisfies the criterion. The lens and prism values are calculated separately from each other and are not to be used

concurrently for treatment. In addition, the equivalent lens values calculated for Sheard's criterion can be adjusted utilizing different AC/A ratios by selecting the desired ratio to the right of the Sheard's calculation box on the main graph page.

**Formula Used:**  $\Delta = [2(\text{phoria}) - \text{fusional reserve}] / 3$

Positive Values indicate failure of this criterion and a need for intervention.

## Percival's Comfort Criterion:

*The zone of comfort should fall within the middle one-third of the range of relative vergence.*

Stated more simply, this criterion states that the true 'free space' demand should fall within the middle third of the relative vergence range (blur values). When plotted on a graph, the demand line should fall within the middle 1/3<sup>rd</sup> of the total relative vergence range. This criterion is best suited for predicting asthenopia in cases of moderate to high esophoria. It is a very poor predictor of symptoms in cases of low esophoria and in any case of exophoria. Using the vergence break values to evaluate this criterion makes it even more sensitive as a predictor of symptoms despite the fact that, classically, blur values were to be used in the calculation. The option to use either blur values or break values is available in the Percival's criterion box on the main graph page. Like Sheard's criterion, Percival's was originally intended for use as a comfort criterion for the nearpoint, but it is also often used in clinical practice as a prescriptive criterion for prism. Like Sheard's, the graphical analysis program provides an evaluation of Percival's for distance as well as for near and calculates both the amount of prism and the equivalent spherical lens necessary to satisfy Percival's criterion. However, since normal 6 m vergence ranges are significantly skewed toward BO, the validity of Percival's *at distance* is highly questionable either as a comfort or a prescriptive criterion. Again, note that both the prism and lens value calculated represent a minimal amount necessary to satisfy Percival's criterion. Those values may or may not allow for optimal function.

**Formula Used:**  $\Delta = [(\text{greater relative vergence}) - 2(\text{less relative vergence})] / 3$

Positive values indicate failure of this criterion and a need for intervention.

## Saladin's Prescription Criterion: One to One Rule

*The base in recovery value should be at least as great as the amount of the esophoria.*

This criterion is designed for use as a prescription criterion for esophoric patients. It is not applicable to exophoric patients. Saladin's Criterion is mostly intended for use at nearpoint, but it can be used as a starting point for prism prescriptions at far as well. For near-only problems, plus lenses can be used in substitution of BO prism in these cases.

**Formula used:**  $\text{BO}\Delta = (\text{esophoria} - \text{BI recovery}) / 2$

Positive values indicate failure of this criterion and a need for intervention.

## Pratt's Prescription Criterion:

*The accommodative and vergence postures should be perfectly balanced.*

Pratt's criterion is strictly a prescriptive criterion designed to derive a nearpoint lens and/or prism prescription to perfectly balance accommodation and vergence postures. AC/A and CA/C ratio information is utilized in order to do this. The main idea behind this criterion is that errors of posture should be equally in error to balance any tug of war between accommodative and vergence postures. By calculating vergence in meter angles (MA), the balance between accommodation and vergence can be easily found since both are then on the same scale (the reciprocal of the demand in meters).

There are two methods that can be utilized in order to calculate Pratt's criterion. One method is graphical and the other is algebraic. For the graphical method, both the AC/A and the CA/C ratio lines are plotted on a graph and then a line is drawn between them along which any point is equidistant horizontally and vertically from the AC/A line and CA/C line respectively. This line is called Pratt's Line. To determine the prism prescription, the horizontal distance between Pratt's line and the 40 cm position on the demand line is measured; and to determine spherical lens power, the vertical distance between the CA/C line and the 40 centimeter position on the demand line is measured. Measured in this way, one is calculating the amount of lens power or prism power to use alone. In order to discern a proper lens/prism combination, one would simply start at the same 40 centimeter free-space position on the demand line and measure any combination of lens and prism power necessary to arrive at Pratt's line.

In order to evaluate Pratt's criterion algebraically, the following formulas are to be utilized:

$$\text{Prism (MA): } P = \frac{Ph + CC}{1 + Cg} \qquad \text{Sphere: } S = \frac{Ph + CC}{1 + Ag}$$

Ph = Phoria in Meter Angles (-) exo and (+) eso

CC = Binocular Cross Cylinder Net relative to the distance subjective refraction

Cg = Gradient CA/C (diopters/meter angle)

Ag = Gradient AC/A (Meter angles/diopter)

**Note:** The formula for prism above results in a meter angle value. This value can easily be translated to an equivalent prism diopter value by multiplying the meter angle value by the patient's distance interpupillary distance in centimeters.

The results of these two formulas would be equivalent to the horizontal and vertical distance of Pratt's line from the 40 centimeter position on the demand line respectively. Combinations of lenses and prisms can be calculated via algebraic methods as well.

Because of the influence of proximal effects, it is best to use a gradient AC/A ratio for this calculation. However, if gradient AC/A ratio data is not available, the near/far AC/A ratio can be used and will probably not significantly change the results provided that considerable proximal effects do not exist for the patient.

Similar to the calculation for the AC/A ratio, calculation of a CA/C ratio requires two measures of accommodative posture in response to a change in vergence demand. The first measure that is almost always used is the fused cross cylinder test at near (#14b). For the other data point, there are two options to choose from. The first is to perform a second fused cross cylinder test at near with the addition of 6 to 12 $\Delta$  of BI prism. The second is to estimate a near far CA/C ratio by simply assuming that accommodative posture is zero at distance or calculate after performing a distance cross-cylinder test. A second fused cross cylinder test at near to figure a near gradient CA/C ratio is the preferred method, but using the near/far CA/C ratio is still acceptable regardless of how it is calculated.

The graphical analysis program evaluates Pratt's criterion via both the graphical and the algebraic method. The default method is based on an *assumed* near-far CA/C ratio as if there were no accommodative error measured at six meters. If the preferred tests are performed, gradient AC/A and or CA/C test data can be entered below the view of Pratt's graph. As this is done, the AC/A and CA/C lines on the graph will change simultaneously along with the calculated sphere and prism values which satisfy Pratt's criterion. Pratt's line does not change automatically. Consequently, the "Re-Plot Pratt's line" button needs to be clicked in order to re-plot Pratt's line on the graph.



# Using the Program:

## Entering Data:

When the program is opened the below "entry form" will be displayed.

Last Name: \_\_\_\_\_ First Name: \_\_\_\_\_ DOB: \_\_\_\_\_ Date: \_\_\_\_\_  
 Occupation: \_\_\_\_\_ Age: \_\_\_\_\_ Time: \_\_\_\_\_  
 Race: \_\_\_\_\_ Gender: ☒ Male ☐ Female  
 Address: \_\_\_\_\_  
 City: \_\_\_\_\_ State: \_\_\_\_\_ Zip: \_\_\_\_\_  
 Intern: \_\_\_\_\_ Attending Doctor: \_\_\_\_\_

**Habitual Rx**  

	Sphere	Cylinder	Axis	Add	Seg Hi	PD
OD			X			
OS						

Uses: \_\_\_\_\_  
 Distance PD: \_\_\_\_\_ NPC Break: \_\_\_\_\_ cm Donders Acc. Amp. \_\_\_\_\_ cm  
 Near PD: \_\_\_\_\_ NPC Recovery: \_\_\_\_\_ cm

**Distance Retinoscopy (#4)**  

OD			X
OS			X

**Max Plus to 20/20 (#7)**  

OD			X
OS			X


**Distance Subjective (#7a)**  

OD			X
OS			X

**BO Vergence at Distance**      **BI Vergence at Distance**  
 /      /  
**BO Vergence at Near (40cm)**      **BI Vergence at Near (40cm)**      **Near Vergence Control Lens**  
 /      /      Distance Refraction ▼

**#14a DCC**      **#14b FCC**      **#15b Phoria**  
 OD \_\_\_\_\_      OD \_\_\_\_\_      \_\_\_\_\_ Exo ▼  
 OS \_\_\_\_\_      OS \_\_\_\_\_

**Analytical Amplitude (#19)**  
 OU \_\_\_\_\_      OD \_\_\_\_\_      OS \_\_\_\_\_  
**PRA (#20)**  
 OU \_\_\_\_\_      OD \_\_\_\_\_      OS \_\_\_\_\_      Phoria \_\_\_\_\_ Exo ▼  
**NRA (#21)**  
 OU \_\_\_\_\_      OD \_\_\_\_\_      OS \_\_\_\_\_      Phoria \_\_\_\_\_ Exo ▼



[Clear Data and Start a New Case](#)  
[Help](#)  
[View Graph](#)  
[View Pratt's](#)

Drag the mouse over red triangles to get more information.
Click to view test descriptions.
Click to view the graph page.
Click to view the Pratt's page.

**Important:** When entering numerical data on the exam form it is important to remember that the graphical analysis program does not correct or round any numbers to the nearest quarter diopter. All numbers should be entered as accurately as possible. Also, make sure to enter a negative "-" sign before all minus lens values to ensure that proper calculations and comparisons can be made. Whenever the graph doesn't look right or numbers don't make sense, check your data entries!

**Demographic Data:**

All of these fields are self explanatory as to what they involve, and are only included for record keeping purposes. It should be pointed out though that nothing can be input into the "Age" field directly. The age of the patient is actually calculated by the program based on the "DOB" and "Date" (of exam) entered into the respective fields. If one or the other of these dates is not entered, then the age of the patient cannot be determined. Again, none of the demographic fields are required to be completed before the graph can be viewed; however, predicted accommodative amplitudes that appear on the graph page cannot be deduced without an age calculation.

**Habitual Rx and Uses:**

Enter the patient's habitual Rx and uses just as you would on a normal exam form. Like the demographic data, these fields are only included for reference purposes.

**Distance and Near Interpupillary Distances:**

Enter the patient's distance and near pupillary distances in millimeters. Unless the PD is <52mm or >68 mm, the graph will automatically be plotted under the assumption that the patient has a 60 mm PD in order to convert prism diopters into meter angles. Seeing as this assumption results in an error of  $2^{\Delta}$  or less (the standardly accepted error inherent in measuring vergences and phoria with Risley prisms) it is an acceptable assumption to make and a practical approach to graphing that is commonly applied. In order to view the graph, a value must be entered for the distance interpupillary distance. The near interpupillary distance is included for reference purposes only.

**Near Point of Convergence (NPC Break and Recovery):**

Enter the patients near point of convergence break and recovery values measured in centimeters. This value is used to determine the vergence amplitude, which is the right hand boundary on the graph and is a measure of the patient's "real world" convergence ability. In order to view the graph, a value must be entered in the "NPC Break". No value is required for the "NPC Recovery." It is included for reference purposes only.

**Donder's Accommodative Amplitude (Nearpoint of Accommodation):**

Enter the patient's nearpoint of accommodation measured in centimeters. This value is used in determining the accommodative amplitude, which serves as the upper boundary on the graph. However, if the amplitude calculated via Donder's method is less than the accommodative amplitude calculated via the analytical amplitude (#19) value or the PRA (#20) value, then the greatest of the three will be used to determine the patient's overall accommodative amplitude and thus the upper boundary of the graph. This value is not required before one can view the graph as long as a value is entered for either the analytical amplitude or the PRA.

**Distance Retinoscopy (OEP #4):**

Enter the result obtained from distance retinoscopy as you would on a normal exam form. This field is included for reference purposes only and is not necessary for any calculations or plots included in this program.

**Maximum Plus to 20/20 (OEP #7):**

Enter the result obtained for the most plus refraction that allows the patient to resolve 20/20 letters on the 6 meter Snellen chart. This component of testing is not necessary for graphical analysis, but it is included for reference and comparison purposes.

**Distance Subjective Refraction (OEP #7a):**

Enter the refraction that allows the patient to achieve his/her best possible acuity level. While only the OD lens value is utilized for analysis purposes, the other fields are included for reference and comparative purposes.

***Induced Distance Phoria (OEP #8):***

Enter the two phoria values obtained from phoria testing at distance through the distance subjective refraction. Even if only one value was obtained, be sure to enter the number in both cells since the phorias are averaged in this program. The direction of the phoria can be specified by selecting either "Eso" or "Exo" from the drop-down menu to the right of the phoria value cells. In the special case where one phoria value was esophoric and the other was exophoric, simply select place a "-" sign in front of the phoria value that is opposite in direction from that specified in the pull down menu.

***Induced Near Phoria (OEP #13b):***

Enter the two phoria values obtained from phoria testing at near through the distance subjective, fused cross cylinder (#14b), or the maximum plus to 20/20 control lenses. The control lens used during testing can be specified via the drop-down menu next to the "13b control lens" label. Even if only one phoria value was obtained, be sure to enter the number in both cells since the phorias are averaged in this program. The direction of the phoria can be specified by selecting either "Eso" or "Exo" from the drop-down menu to the right of the phoria value cells. In the special case where one phoria value was esophoric and the other was exophoric, simply select place a "-" sign in front of the phoria value that is opposite in direction from that specified in the pull down menu.

***Distance Vergence Measures (OEP #9, 10, 11):***

Enter the blur, break, and recovery values (in prism diopters) obtained for both BO and BI vergence range testing at distance. The control lens used should be the distance subjective refraction. Under normal circumstances, a blur value will not be reported during BI vergence testing. In that case, simply enter an "X" for the blur value under "BI vergence at distance." The graphical program will then automatically use the break value in place of the absent blur value. The same thing should be done for the BO to blur value if a blur is not reported.

***Near Vergence Measures (OEP #16a, b and 17a, b):***

Enter the blur, break, and recovery values (in prism diopters) obtained for both BO and BI vergence range testing at near. As for the induced phoria value at near, the control lens used during near vergence testing can be specified by simply selecting it from the pull-down under "Near Vergence Control Lens." As with distance vergence measurements, record an "X" for the blur value if no blur was reported during either BO or BI vergence testing. The graphical program will then automatically use the break value in place of the absent blur value.

***Dissociated Cross Cylinder (OEP #14a):***

Enter the OD and OS gross spherical lens values obtained from the dissociated cross cylinder lens test. These values are not necessary for graphical analysis, but they are included for reference and comparison.

***Fused Cross Cylinder (OEP #14b):***

Enter the OD and OS gross spherical lens values obtained from the high neutral fused cross cylinder lens test. Only the OD lens value is used for graphical analysis purposes.

***Fused Cross Cylinder Induced Phoria (OEP #15b):***

Enter the two phoria values obtained from phoria testing at near through the fused cross cylinder control lenses. Even if only one phoria value was obtained, be sure to enter the number in both cells since the phorias are averaged in this program. The direction of the phoria can be specified by selecting either "Eso" or "Exo" from the drop-down menu to the right of the phoria value cells. In the special case where one phoria value was esophoric and the other was exophoric, simply select place a "-" sign in front of the phoria value that is opposite in direction from that specified in the pull down menu.

### **Analytical Amplitude (OEP #19):**

Enter the gross spherical lens values obtained from analytical amplitude testing. Under normal circumstances, only the binocular version of this test will be performed; however, the monocular lens values can be entered for reference purposes if they are acquired. Only the OD sphere value of the binocular test is utilized within the program for analysis. In the absence of values for both Donder's and the PRA, the analytical amplitude serves as the sole estimation of the patient's accommodative amplitude. If the PRA, Donder's or both are performed in addition to the analytical amplitude, then the program will select the greatest estimation of accommodative amplitude to be used as the top boundary of the graph.

### **Positive Relative Accommodation or Binocular Minus to Blur (OEP #20):**

Enter the gross spherical lens values obtained from positive relative accommodation testing. While only the OD sphere value is necessary for analysis and proper generation of the graph, the other fields are present for reference purposes. In the absence of values for the analytical amplitude (#19) and Donder's, the PRA serves as the sole estimation of the patient's accommodative amplitude. If the analytical amplitude and Donder's are both performed in addition to the PRA, then the program will select the greatest estimation of accommodative amplitude to be used as the top boundary of the graph.

### **Negative Relative Accommodation or Binocular Plus to Blur (OEP #21):**

Enter the gross spherical lens values obtained from negative relative accommodation testing. While only the OD sphere value is necessary for analysis and proper generation of the graph, the other fields are present for reference purposes.

**NOTE:** *Many clinicians habitually record net values for BCC, NRA, PRA, etc. However, since there is no perfect agreement among practitioners as to what the universal reference lens should be, it has been decided to have gross lens values entered to avoid interpretation difficulties.*

### **Navigation Buttons:**

#### **Help**

Clicking on this button will bring up a help menu that provides a general description of each of the tests listed on the entry form. If you have any questions about how to properly perform a test, this is the place to look for a quick reference.

#### **View Graph**

Clicking on this button will take you to the main graph page where you can view the graph and evaluate case data via calculations of Donder's, Sheard's, Percival's, and Saladin's criteria. You will not find a complete nor accurate graph unless all necessary data has been entered. Before showing the graph, the program checks to make sure that you have entered a value into all the necessary fields, and it will tell you which ones you still need to enter.

#### **View Pratt's**

Clicking on this button will take you to the Pratt's evaluation page where you can view a fully calculated and graphed representation of Pratt's criterion. In addition, you can manipulate the data on Pratt's page if the necessary additional testing has been performed. Before showing you Pratt's evaluation page though, the program checks to see that all necessary information has been entered. You will then be told which data values are required in order to proceed.



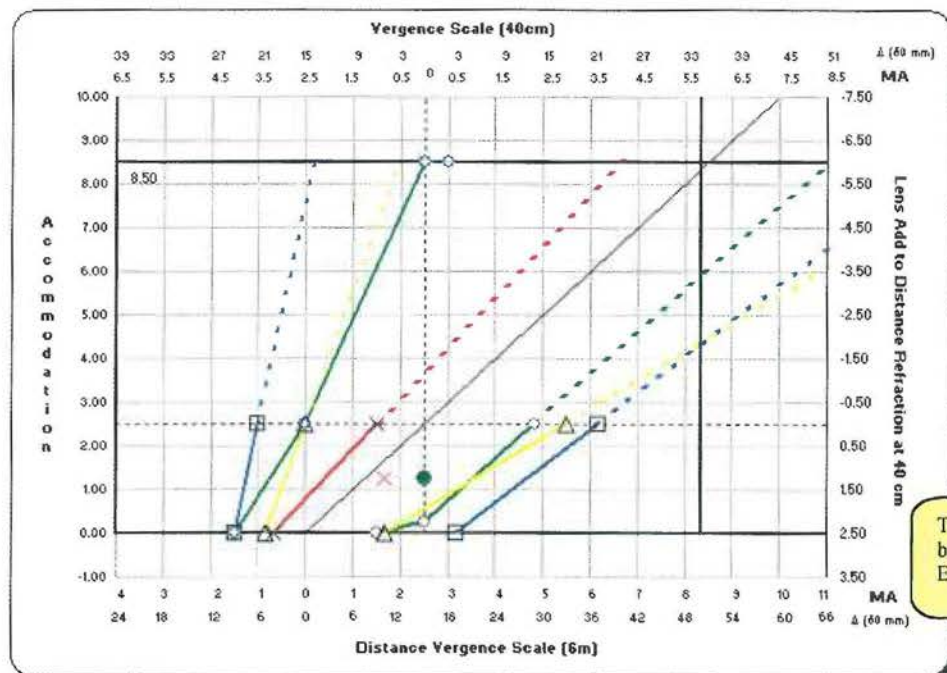
# Using the Graph Page:

Demographic data is automatically transferred from entry page.

Last Name:  
First Name:  
Gender: Male  
DOB:

Age:  
Race:  
Occupation:  
Refraction (7a)  
OD 1.00 DS X 0  
OS 0.00 DS X 0

Date of Exam:  
0-Jan-00



- Legend**  
(Holding the cursor over any datapoint will reveal it's (x,y) values)
- Phoria (AC/A)
  - Prism Break
  - Prism Elur
  - Prism Recovery
  - Demand Lines
  - #14b (FCC) net

Takes you to Pratt's page.

Takes you to back to the Exam Form.

View Pratt's

View Exam Form

Calculated Near/Far AC/A Ratio:

5.2

Gradient AC/A Ratios:

#13b-#15b  
#13b-#21p

0.8  
2.7

p.d./D  
p.d./D

Print Data

Predicted Acc. Amplitude  
Max:  
Avg: Need Age  
Min:

Calculates predicted amplitudes via Hofstetter's formulae and the patient's age.

Print's out the entire graph page.

## Comfort and Prescriptive Criteria:

### Donder's Accommodative Criteria:

Patient has an adequate accommodative amplitude according to this criterion

Recommended Add: 0.00 D

### \*Saladin's Prescription Criteria:

N/A Prism Diopters BO

Pass / Fail: N/A

Not applicable. Patient is exop

Any AC/A can be entered to calculate an equivalent lens.

### Sheard's Comfort Criteria:

	Recommended Prism	Base Direction	Pass / Fail	Equivalent Lens (D)
Distance:	-0.33	N/A	PASS	- N/A
Near:	-0.67	N/A	PASS	- N/A

Which AC/A ratio calculate the Equivalent Lens?

- ☒ #13b - #15b ☐ Other (Enter Right)  
☐ #13b - #21p ☐ Calculated Near/Far

Other AC/A

7

### Percival's Criteria

Do you want to use the relative blur or break values for these calculations?

BREAK

	Possible Prism	Base Direction	Pass / Fail	Equivalent Lens (D)
Distance:	0.33	Base Out	FAIL	0.42
Near:	-0.67	N/A	PASS	N/A

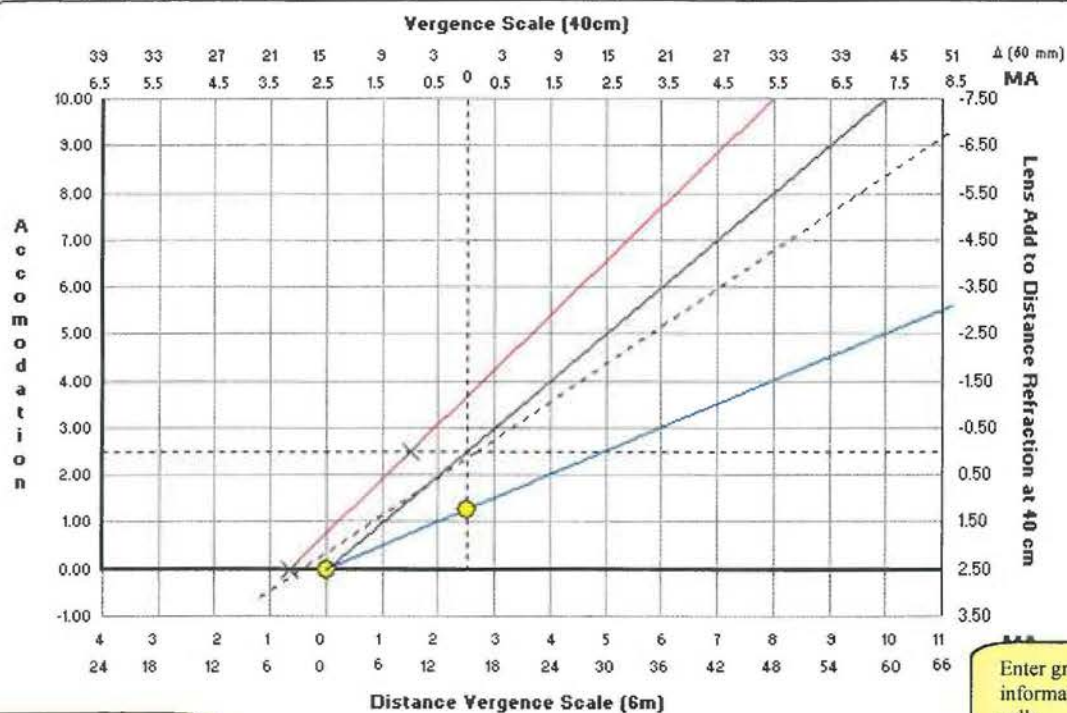
You can select whether you use blur or break vergence values to calculate Percival's

You can select the AC/A ratio that is used to calculate an equivalent spherical lens for the prism amounts calculated for both Sheard's and Percival's criteria.

\* Both Sheard's and Percival's Criteria were originally contrived for application for near only.

\* Saladin's Prescription Criterion was designed strictly for esophoria prescriptions and is most applicable for distance as well.

## Using Pratt's Page:



Enter gradient AC/A information in these cells. Make sure "Yes" is selected if additional data is entered.

Do you want to change the AC/A line gradient AC/A?

☒ NO

Do you want to change the CA/C line?

How much base in prism did you add?

0

What was the #14b lens value after this?

0.00

What was the measured phoria value?

ESD

How much plus did you add?

0.00

Re-Plot Pratt's Line

Recommended Sphere:

0

Recommended Prism (Pd):

Click this button to go back to the graph page.

View Graph

Click this button to go back to the entry page.

Back to Exam Form

If additional CA/C and/or AC/A data is input into the appropriate cells click this button to re-plot Pratt's line on the graph

Print Pratt's

Click this button to print back a hard copy of Pratt's page.

## References

### Graphing:

- Amos. Diagnosis and Management in Vision Care. Butterworth-Heinemann. 1987. pp. 433-434, 462-463, 480-481
- Birnbaum, M. Optometric Management of Nearpoint Vision Disorders. Butterworth-Heinemann. 1993. pp. 97-117
- Goss, D.A. Ocular Accommodation, convergence, and Fixation Disparity: A manual of Clinical Analysis. 2<sup>nd</sup> Ed. Newman, MA: Butterworth and Heinmann, 1995. pp. 1-61
- Grosvenor. Primary Care Optometry, 3<sup>rd</sup> ed. Butterworth-Heinemann. Pp. 369-371

### Criteria:

#### Donder's Criterion:

- Goss, D.A. Ocular Accommodation, convergence, and Fixation Disparity: A manual of Clinical Analysis. 2<sup>nd</sup> Ed. Newman, MA: Butterworth and Heinmann, 1995. pp. 121-123

#### Pratt's Prescription Criterion:

- Goss, D.A. Ocular Accommodation, convergence, and Fixation Disparity: A manual of Clinical Analysis. 2<sup>nd</sup> Ed. Newman, MA: Butterworth and Heinmann, 1995. pp. 188-190

#### Sheard's Criterion:

- Birnbaum, M. Optometric Management of Nearpoint Vision Disorders. Butterworth-Heinemann. 1993. pp. 100-101
- Goss, D.A. Ocular Accommodation, convergence, and Fixation Disparity: A manual of Clinical Analysis. 2<sup>nd</sup> Ed. Newman, MA: Butterworth and Heinmann, 1995. pp. 47-52

#### Percival's Criterion and Saladin's One-to-One Criterion:

- Birnbaum, M. Optometric Management of Nearpoint Vision Disorders. Butterworth-Heinemann. 1993. pp. 98-101
- Goss, D.A. Ocular Accommodation, convergence, and Fixation Disparity: A manual of Clinical Analysis. 2<sup>nd</sup> Ed. Newman, MA: Butterworth and Heinmann, 1995. pp. 53-62